Study of the cluster splitting algorithm for the EMC

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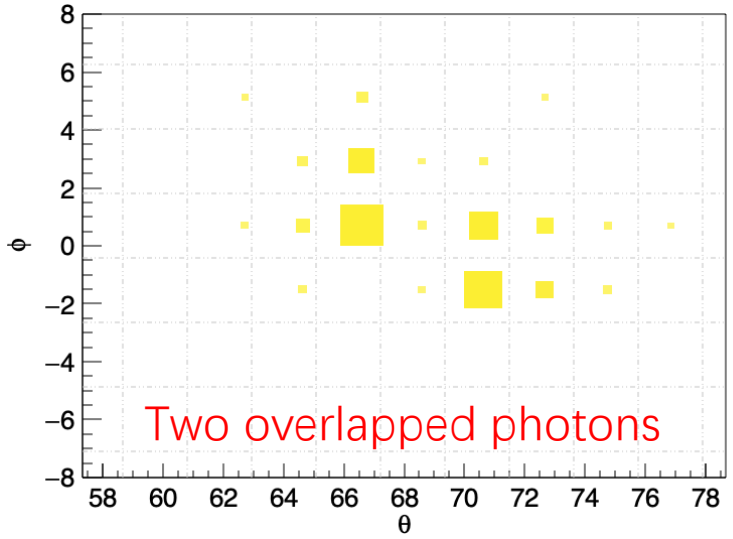
Outline

- Introduction
- Study of the cluster-splitting algorithm
- Preliminary results
- Summary

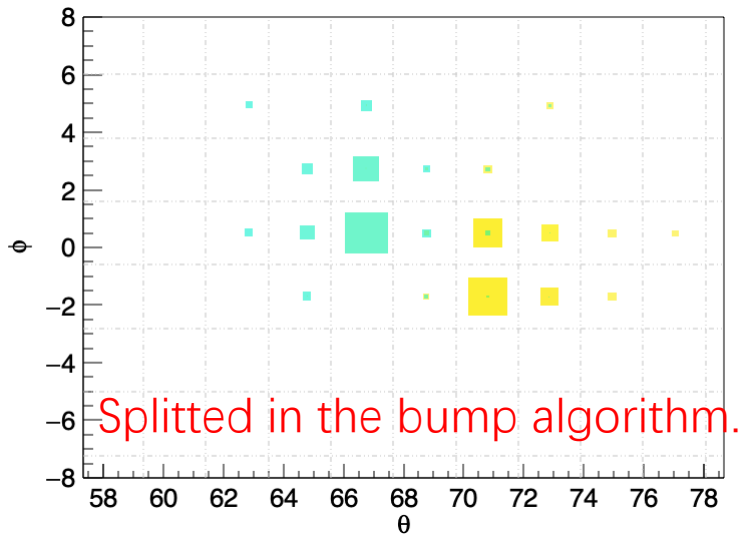
Introduction

- Cluster-splitting is an important algorithm in EMC reconstruction
- The purpose of the cluster-splitting is to separate clusters that are close to each other.
- An MC truth tool is developed to obtain the energy-fraction information in overlapped clusters (see my talk in the last collaboration meeting)
- In this work, we will study the cluster-splitting algorithm using the tool.

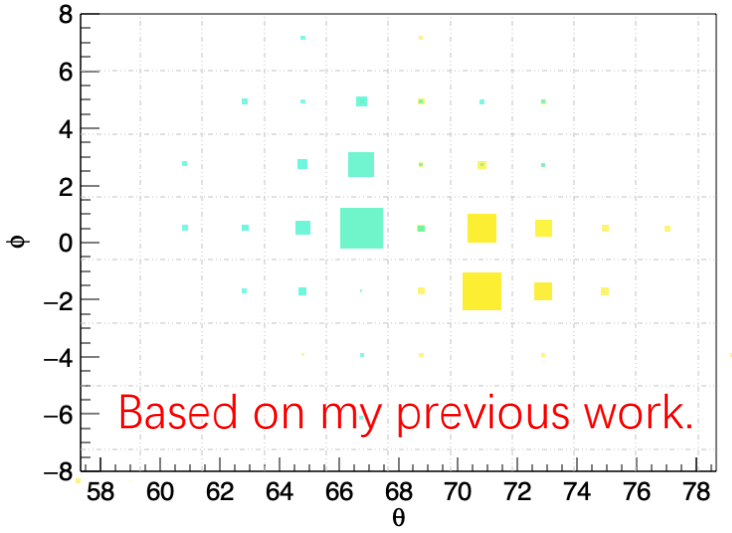
Energy distribution of Cluster



Energy distribution of Bump



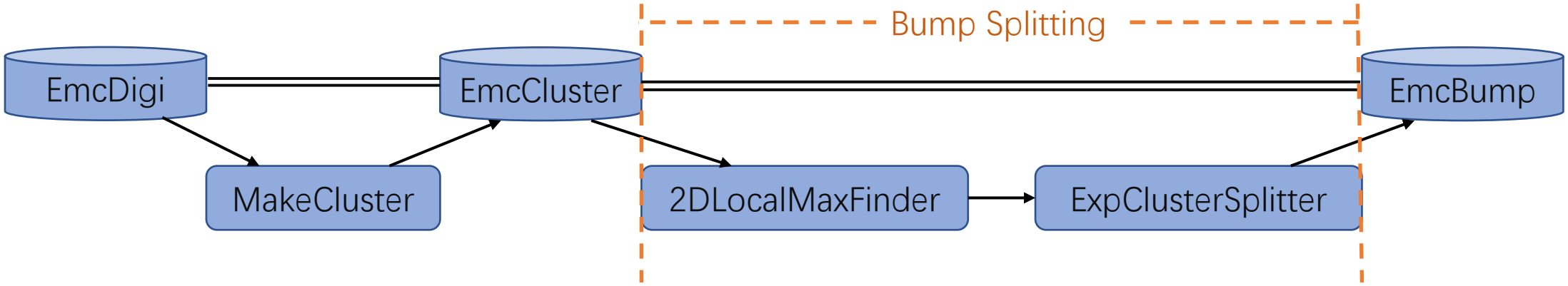
Energy distribution of MC-truth



EMC reconstruction overview

1. Cluster finding: a contiguous area of crystals with energy deposit.

2. The bump splitting
   - Find the local maximum: Preliminary split into seed crystal information
   - Update energy/position iteratively
     - The spatial position of a bump is calculated via a center-of-gravity method
     - The crystal weight for each bump is calculated by a formula.



Update energy/position iteratively

- Initialization:
  Place the bump center at the seed crystal.

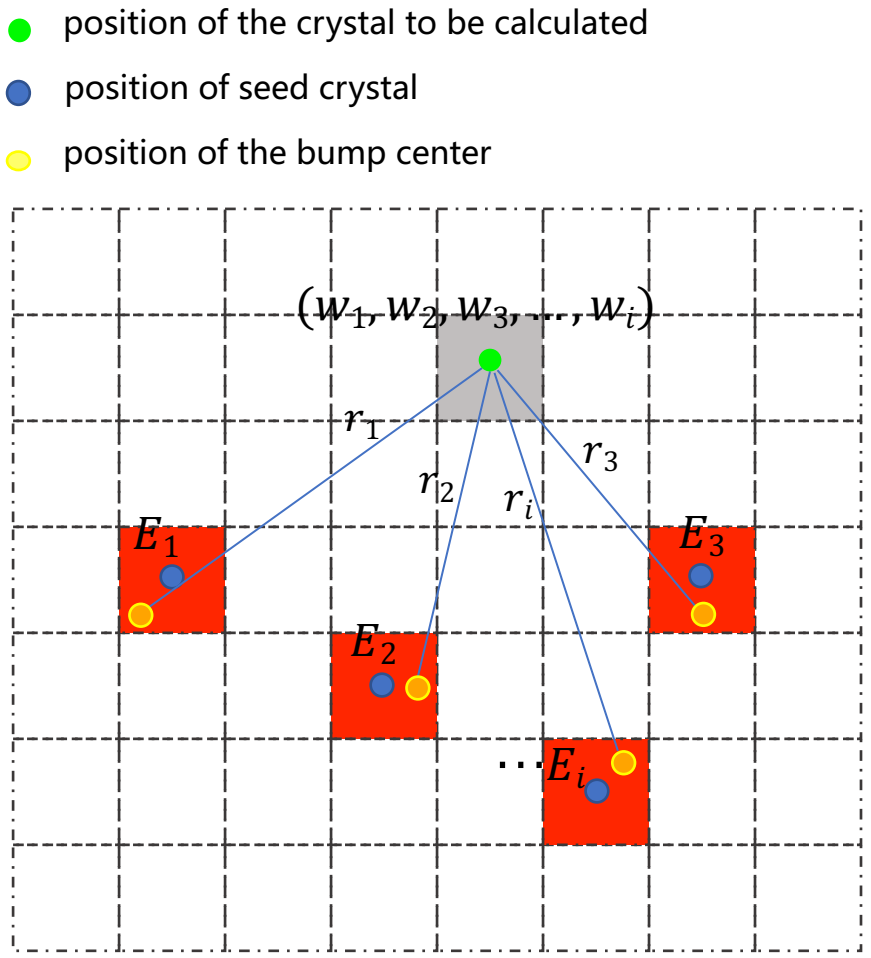
- Iteration:
  1.Traverse all digis to calculate w_i.

$$w_i = \frac{E_i \exp(-2.5 r_i / r_m)}{\sum_j E_j \exp(-2.5 r_j / r_m)}$$

i or j : different seed crystals
r_m = Moliere radius

2. Update the position of the bump center.

3. Loop over 1 & 2 until the bump center stays stable within a tolerance of 1 mm or the number of iterations exceeds the maximum number of iterations.



The weighting formula

Energy deposition from a seed:

$E_{ci}(r_{ci}) = E_i \exp(-2.5 r_{ci}/r_m)$

the two cases on the right have the same calculation result. But the actual situation is not like this.

E_i depends not only on r_{ci} , but also on the distance from the bump center to the seed crystal r_i.

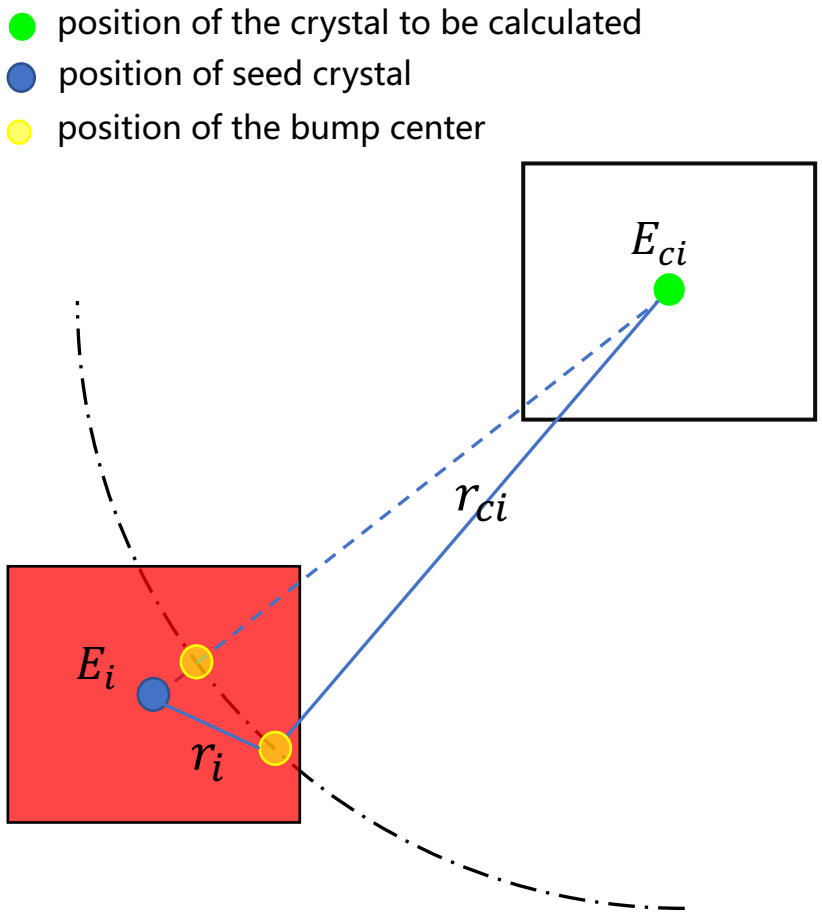
Symbol Description:

c means the current calculated crystal.

i is used to mark different seed crystals. $(i = 1,2,3, \dots, N_{seed})$

E_{ci}: the deposition energy of the photon corresponding to the seed crystal i in the current crystal.

E_i: the energy of the seed crystal.



The weighting formula update (I)

Assuming that the bump center is located in the center of the seed crystal, there is the following function

$E = E_s f(r)$

E_s: the energy of the seed crystal. s = energy source

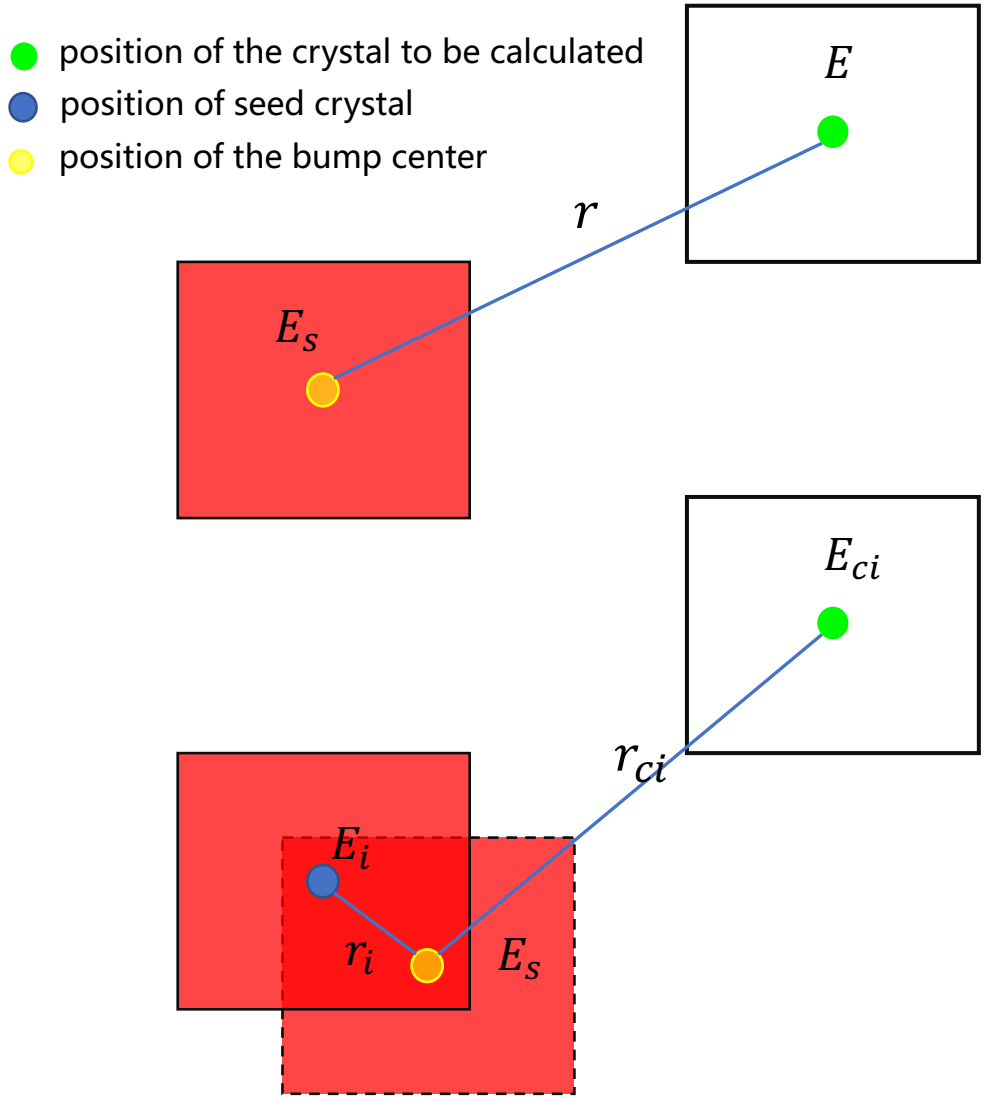
It can be obtained when the bump center is not in the center of the seed crystal :

$E_{ci} = E_s f(r_{ci}),\qquad E_i = E_s f(r_i)$

So ,

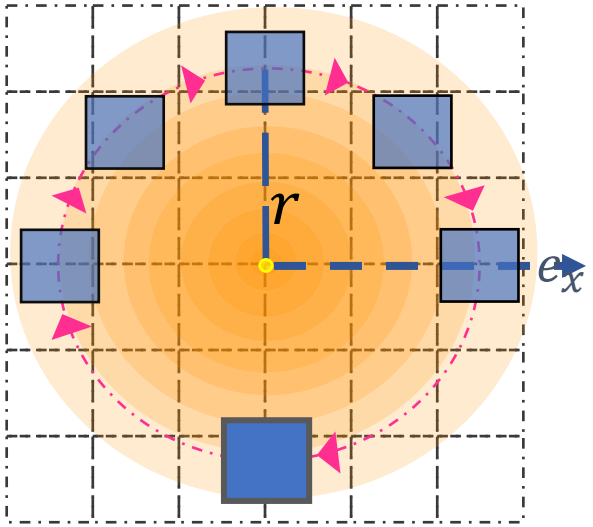
$E_{ci} = E_i f(r_{ci})/f(r_i)$

- Compared with the algorithm in the library, the position information of the shower center in the seed crystal is increased.



The weighting formula update (II)

Assuming a certain distance, the deposition energy of crystals at different azimuths relative to the center of the shower is different.



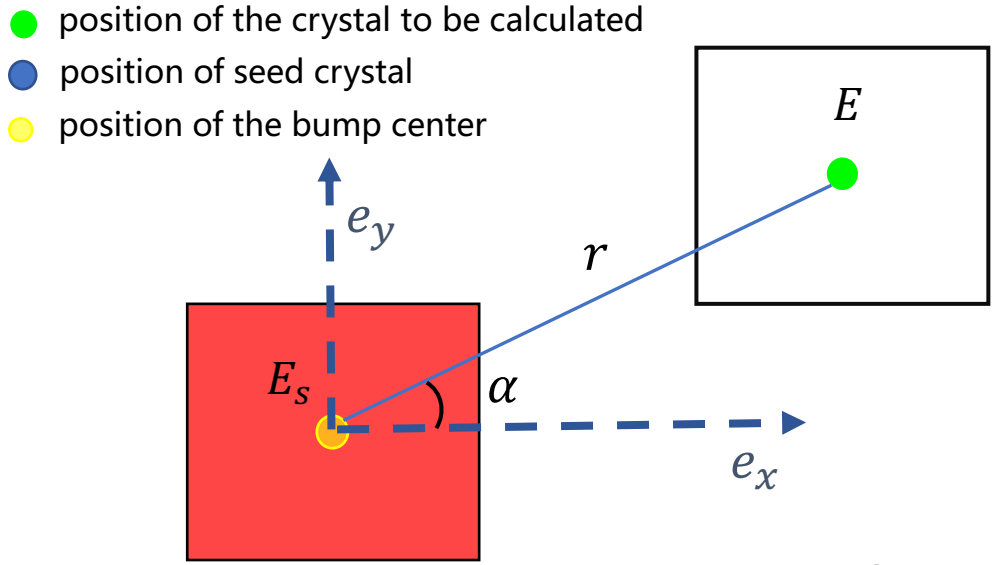
Define the azimuth as α.

The calculation formula is rewritten as

$E = E_s f(r, \alpha)$

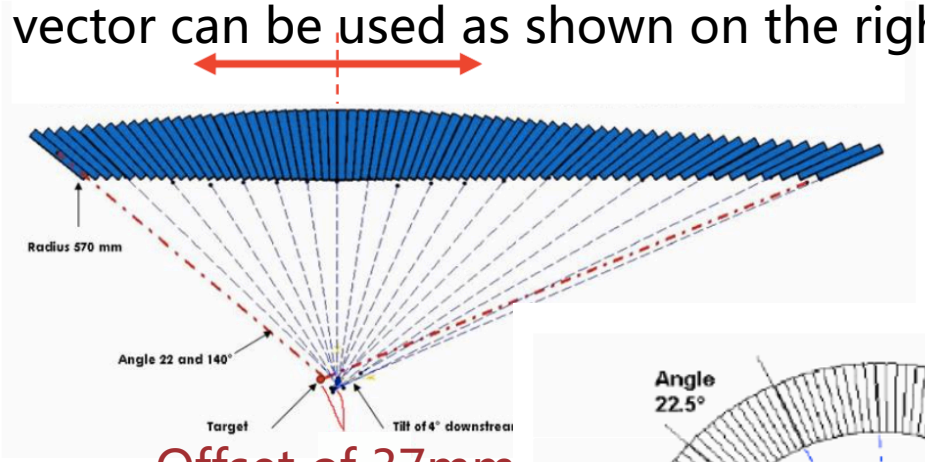
So ,

$E_{ci} = E_i f(r_{ci}, \alpha_{ci}) / f(r_i, \alpha_i)$

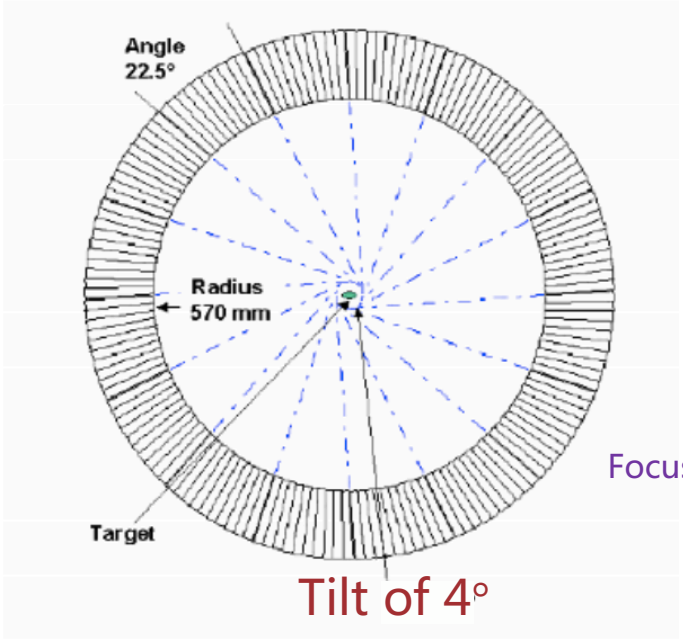


Calculation of angle in algorithm

Considering the detector geometry, the normal vector can be used as shown on the right.



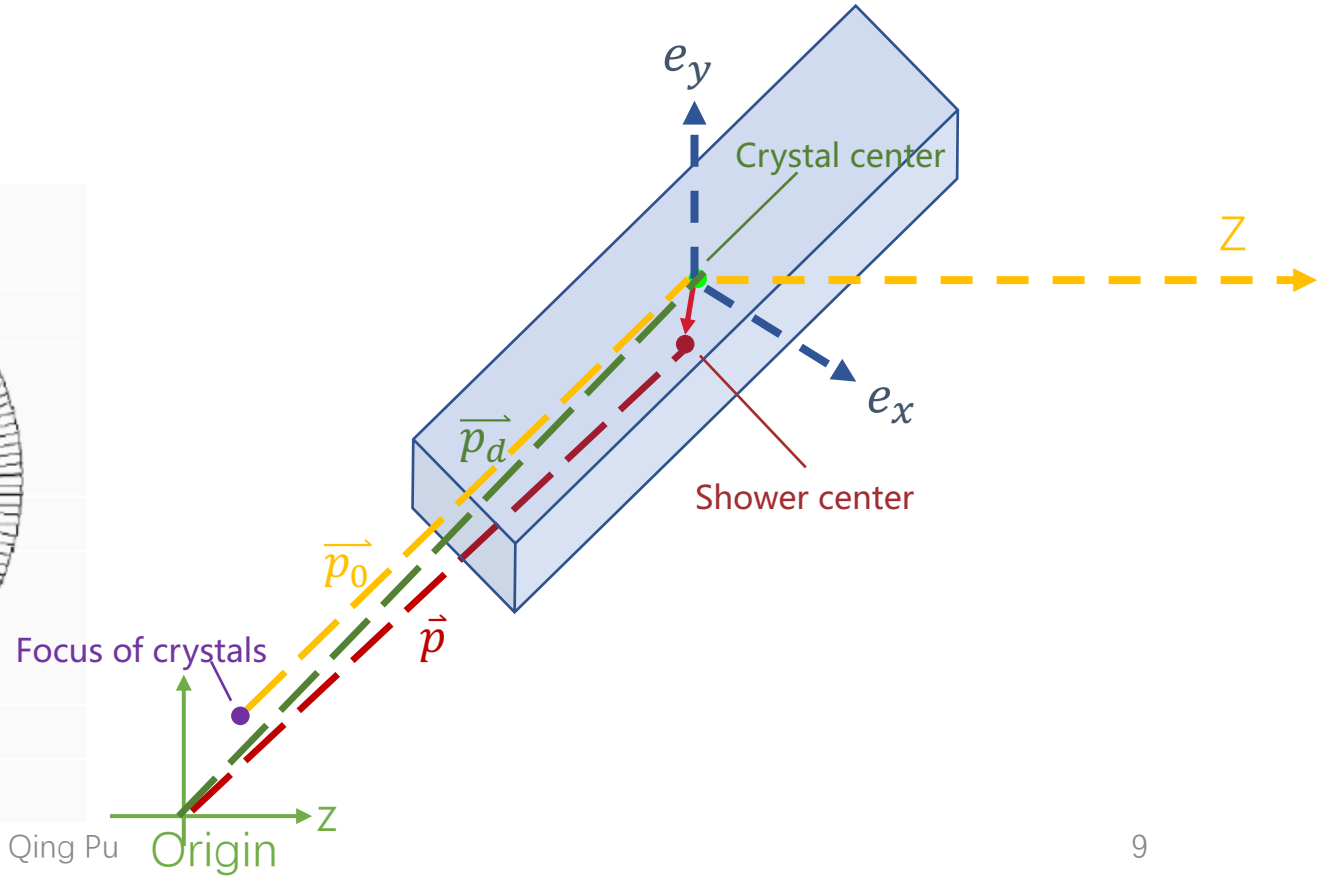
Offset of 37mm



Tilt of 4°

$$\overrightarrow{p_0} = RotPhi(\overrightarrow{p_d} - (0, 0, 3.7),\ 4°)$$

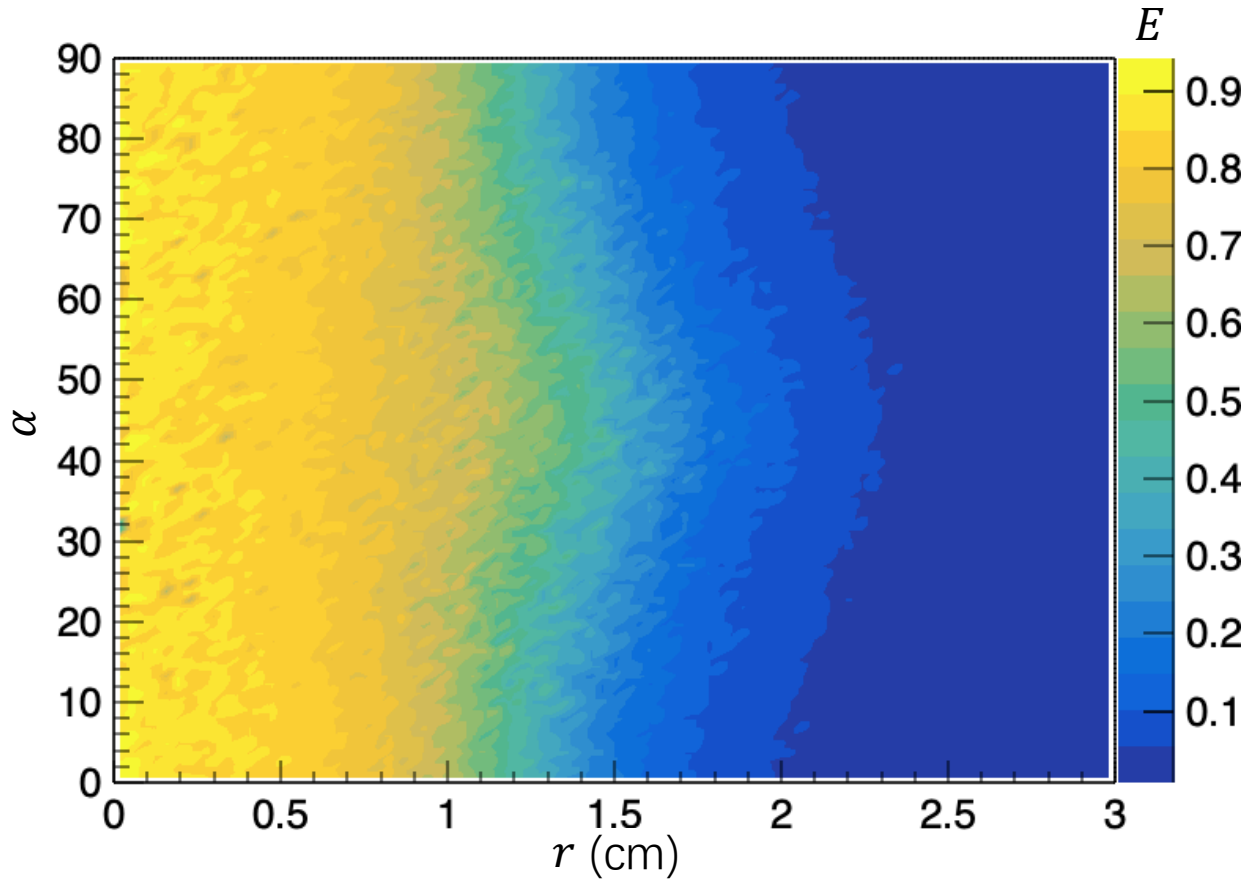
$$tan\alpha = \frac{(\vec{p} - \overrightarrow{p_0}) \cdot \overrightarrow{e_y}}{(\vec{p} - \overrightarrow{p_0}) \cdot \overrightarrow{e_x}} \qquad \left(\overrightarrow{e_y} = \frac{\overrightarrow{p_0} \times \vec{Z}}{|\overrightarrow{p_0}|},\ \overrightarrow{e_x} = \frac{\overrightarrow{p_0} \times \overrightarrow{e_y}}{|\overrightarrow{p_0}|} \right)$$



Implement angle dependent functions

In order to get the $f(r,\alpha)$, I generated 50,000 1GeV single-photon entries and counted the distance and angle from the center of the shower.

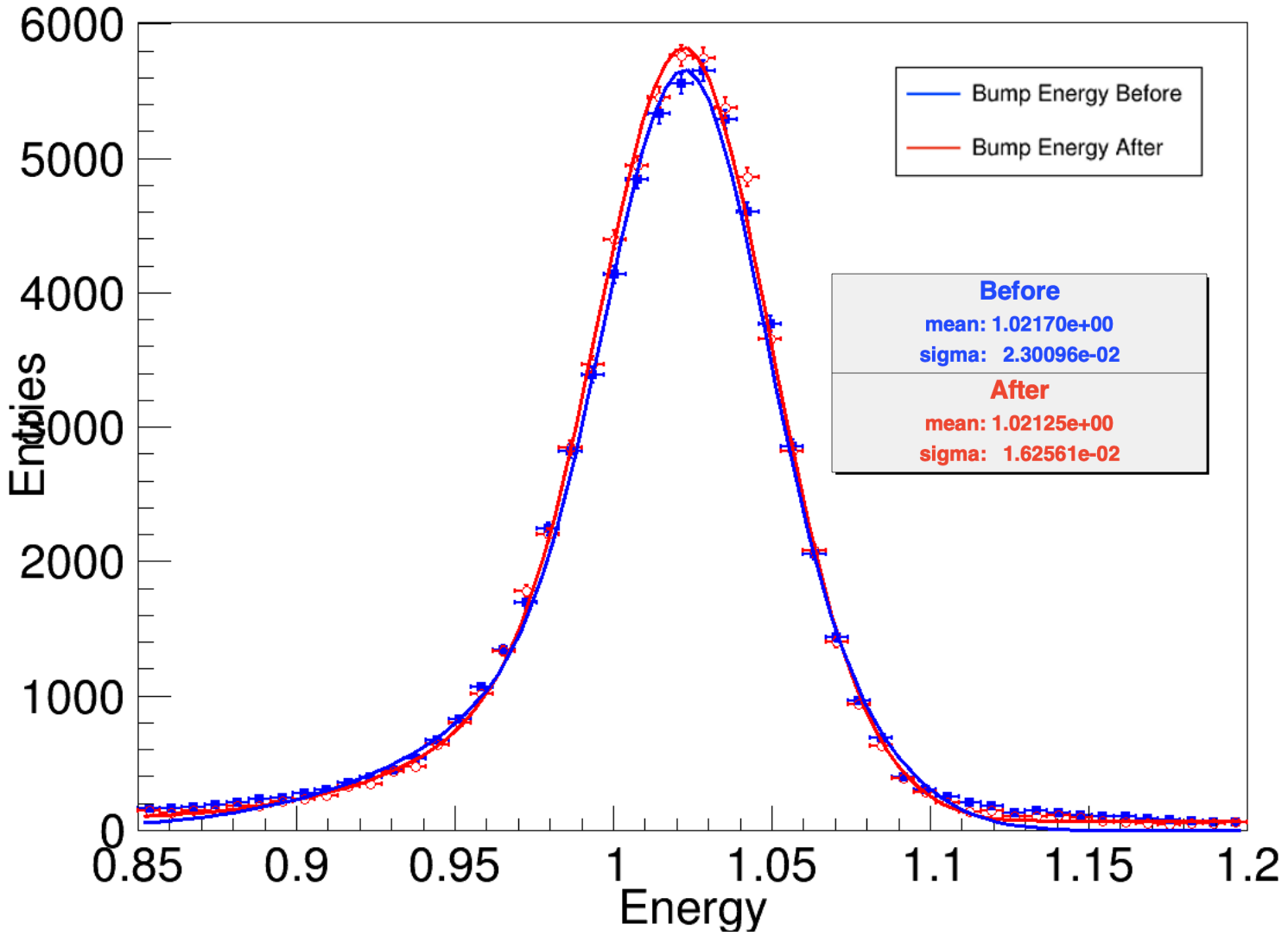
- The energy deposition has obvious angular dependence.
- By fitting the graph on the right we can get $f(r,\alpha)$.
- Apply function $f(r,\alpha)$ to the cluster-splitting algorithm.



Preliminary Results

- Gamma Gamma (1GeV)
- Events 50000
- Geant3
- Generator: Box
- Phi(-10, 10)
- Theta(60, 80)

- It can be seen that the resolution has been improved



Function used for fitting : Novosibirsk function

$$f(E) = A_S \exp(-0.5\ln^2[1 + \Lambda\tau \cdot (E - E_0)]/\tau^2 + \tau^2)$$

Summary

- A preliminary study of the cluster-splitting algorithm is presented
- The angle and position dependency is added to the bump-weighting formula
- Test the new bump-splitting algorithm with MC-truth information. The preliminary results show slightly better resolution
- Photons of different energy and angle will be considered later.

Thank you for your attention!